

SEPTEMBER 16, 1993

**NATIONAL CLIMATIC DATA CENTER
RESEARCH CUSTOMER SERVICE GROUP**

TECHNICAL REPORT 93-04

**THE SUMMER OF 1993:
FLOODING IN THE MIDWEST AND
DROUGHT IN THE SOUTHEAST**

**NEAL LOTT
PHYSICAL SCIENTIST**

THE SUMMER OF 1993:

FLOODING IN THE MIDWEST AND DROUGHT IN THE SOUTHEAST

INTRODUCTION

During the past summer, the Upper Midwest has been devastated by severe flooding, while parts of the Southeast have been hit by a heat wave and drought. This report provides a review of the details gathered thus far about these events. It includes information provided by the National Climatic Data Center, the Climate Analysis Center, the National Weather Service, the Midwestern Climate Center, and various news media reports.

MIDWEST FLOODING

- 1) The stage was set for severe flooding when the upper drainage basin of the Mississippi River experienced a wet fall in 1992 followed by heavy winter snowfall and the ensuing spring snowmelt. (Iowa reported its greatest snowpack since after the winter of 1978-79.) Severe flooding began in May on the Redwood River in Minnesota, and then in June on the Black River in Wisconsin. Then came the record flooding of the Mississippi, Missouri, and Kansas Rivers. The most severe flooding was concentrated along a 500-mile stretch of the Mississippi River between Cairo, IL and Minneapolis, MN; and along a 400-mile length of the Missouri River from Omaha, NE to St. Louis, MO. Some sections of the Mississippi River were above flood stage from late March through most of August. Also, some areas were flooded which were outside of the 100-year flood plain charts (for previous flooding).
- 2) The Missouri River crested in St. Charles, MO at 39.3 feet, and in Kansas City at 48.8 feet--17.5 feet above flood stage. The Mississippi River at St. Louis crested at 49.6 feet--19.6 feet above flood stage. The old record for the Missouri River at Kansas City was 46.2 feet in 1951. The old record for the Mississippi River at St. Louis was 43.2 feet in 1973. Also, the Kansas River at Kansas City crested at 54.9 feet--22 feet above flood stage, and 3.9 feet above the old record.
- 3) Des Moines, IA residents were without water for 12 days due to flooding of their water supply facilities. This is the largest U.S. city (250,000 population) to go without water for such an extended period. The Raccoon River in Des Moines crested at 7 feet over its previous all-time record crest. Some estimates indicated this to be a 500-year flood event for the Des Moines area. Also, 85,000 people were without water in St. Joseph, MO; along with 77,000 people in Alton, IL.

4) Due to flooding of many of the major roadways and interstates, 'commuting' distances grew from several miles to over 200 miles in some instances. Many of the bridges crossing the Mississippi were destroyed or damaged by the flooding. From July 16-20, there were no bridge crossings over a 212-mile span between Burlington, IA and St. Louis, MO. Also, there was no MS River traffic over a 585-mile span from Cairo, IL to St. Paul, MN from late June through early August, resulting in over 5000 loaded barges being halted, and an estimated \$3 million per day in lost revenue. Similarly, the Missouri River was closed from late June through early August over a 535-mile span stretching from its confluence with the Mississippi River to near Sioux City, IA. Eleven commercial airports were closed at one time or another due to the flooding. Also, railway traffic was devastated, with over 4000 miles of track either flooded or idled, and over \$200 million in estimated losses so far.

5) Well over 17 million acres were flooded, covering parts of 9 states. More than 22,000 homes were damaged or destroyed, and over 85,000 residents had to evacuate their homes. More than 75 small towns near the rivers were completely flooded. Some of the flooding occurred as levees collapsed after being weakened by constant pressure from rising water levels. However, some levees, such as the 52-foot 'wall' protecting St. Louis, held back the rising waters. It is interesting to note that the St. Louis levee was built to a level 9 feet higher than the previous record crest for the Mississippi River, but less than 3 feet higher than the 49.6-foot crest recorded on August 1. Over 6500 National Guard members were called in to assist in levee work. A recent report on the various levees on the Mississippi and Missouri Rivers indicates the following:

Federal levees (mostly Army Corps of Engineers)--20 of 275 have been overtopped or breached.

Non-federal and private levees--767 of 1091 have been overtopped or breached.

6) Over 16,000 square miles of farmland were flooded, and crop losses are expected to exceed \$5 billion. Many farm animals, such as cattle, have perished in the rising waters. Total crop losses due to flooding or saturated fields now exceed 35 million acres. The national soybean yield is now forecast to be 13 percent below last year's level, while the national corn yield is expected to be down by 22 percent. Soybean prices moved to 4-year highs on July 10 due to the damage assessments.

7) Overall damage estimates at this point are quite preliminary, but already exceed \$12 billion. Also, the 'economic' costs of lost business revenue will have to be factored in at some point. Local power plants were damaged in many cities, with electrical service lost as a result (including 45,000 people without power in Des Moines). Business districts were flooded in Davenport, Dubuque, Burlington, and many other smaller towns. The overall death toll from the flooding now stands at 48. Many church groups across the nation have responded by sending money, food, supplies, and personnel assistance to flooded areas.

8) The Missouri River, normally no more than a half-mile wide, expanded to 5-6 miles wide north of St. Joseph, MO, and 8-10 miles wide east of Kansas City. Just north of St. Louis, it reached 20 miles wide near its confluence with the Mississippi, as the merging of the 2 rivers occurred 20 miles north of their normal point of confluence. As a result, almost half of the 620 square miles of St. Charles County, MO were underwater. Also, the Red River in North Dakota reached a level of 32 feet--21 feet above flood stage.

9) 404 counties in the Midwest have been declared federal disaster areas (all of IA, 62% of MO, 58% of WI and ND, 52% of SD, 46% of NE, 40% of MN, 25% of IL, and 22% of KS). In Alexandria, Mo, flood waters reached depths of 8-10 feet, while Kansas City residents found water 7 feet deep in places. In Eden Prairie, Wisconsin, many people were stranded in floating cars (including police officers), and manhole covers were 'blown' into the air by the water pressure. Near Bismarck, ND, a severe thunderstorm with very large hail stranded 3 girls in the Missouri River--all 3 were injured by the hail but survived the ordeal. In Iowa, measurable rainfall fell somewhere in the state for 33 consecutive days from June 22nd to July 25th, and the state has endured 10 consecutive months (through August) of above normal rainfall. There have even been reports of snakes floating along on top of propane tanks set adrift by the rising waters.

10) The waters in some areas remained above flood stage for many weeks, and receded rather slowly. Many locations experienced not one, but two record crests during the flooding. Continuation of heavy rainfall in some areas during August further delayed the river levels' fall. However, the Mississippi River at St. Louis recently subsided to below flood stage for the first time since June.

11) Mississippi River watershed 1993 precipitation was the greatest since 1895 for the following periods: July, June-July, May-July, and April-July.

12) Rainfall totals have been phenomenal. For example, Papillion, NE (just south of Omaha) reported 1 inch of rain in 6 minutes during a thunderstorm. Several locations in Nebraska and other states reported 12-inch rains in 48-hour periods. In Adrian, MN, after a 7-inch rainfall in a little over an hour, a 3-foot wall of water rushed through the town causing severe damage, and even ripping away large chunks of asphalt from the streets. (Keep in mind that 1 inch of rain equals 27,143 gallons of water on 1 acre of land.) There was even an unofficial report from New London, IA of 6.5 inches of rain during a 15-minute cloudburst!

13) The combined totals for June-July are equally impressive. Wisconsin, Iowa, and Illinois had their wettest June-July period on record (since 1895), while Minnesota had its 2nd wettest. Iowa, the Dakotas, and Montana had their wettest July on record, while Iowa also had its wettest August on record. Following are some of the more impressive rainfall totals:

Cedar Rapids, IA--34.44 inches for April-July and Salina, KS--37.22 inches for April-July--both exceeding their annual average in just 4 months.

Northwest and north-central Missouri generally received between 15 and 25 inches of rainfall for July, with some stations receiving 1.5 to 2.5 times the previous record total for July. (This contrasts with some locations in the southeast bootheel receiving less than 1 inch for July.)

Record monthly totals of greater than 10 inches (NWS offices):

June--	July--
Moline, IL (13.21)	Concordia, KS (16.75)
Rockford, IL (11.85)	Bismarck, ND (13.75)
South Bend, IN (10.86)	Grand Isle, NE (10.68)
Waterloo, IA (10.11)	Peoria, IL (10.15)

Record June-July combined totals (NWS offices):

Location	New Record	Old Record	Normal	1993--
				% of Normal
Chicago IL	14.4	11.2 -- 1970	7.4	195
Moline IL	19.0	18.4 – 1969	9.2	207
Springfield IL	16.8	16.6 -- 1981	6.9	243
Dubuque IA	16.5	15.9 – 1969	8.2	201
Waterloo IA	21.4	17.6 – 1990	9.3	230
Concordia KS	23.5	18.8 – 1967	8.1	290
Grand Island NE	15.6	14.9 – 1967	6.7	233
Norfolk NE	15.4	13.4 – 1950	7.7	200
Omaha NE	17.7	14.2 – 1967	7.2	246
Bismarck ND	18.4	8.2 – 1963	4.9	376
Fargo ND	12.0	11.8 – 1975	5.5	218
Grand Forks ND	11.6	11.4 – 1968	5.6	207
Williston ND	10.1	9.2 – 1963	4.4	230
Aberdeen SD	13.6	11.3 – 1939	5.9	231
Huron SD	13.8	13.3 – 1984	6.0	230
Sioux Falls SD	14.3	13.5 – 1948	6.1	234
Green Bay WI	13.6	13.2 – 1990	6.5	209

Other notable amounts:

6/13/93--4 inches in 1 hour in Lenox, IA.

6/23/93--10 inches in 4 hours near Armstrong, IA.

11 inches (during afternoon) in Hamms Park, MN

(9 inches fell in 2 hours).

6/30/93--7 inches in 4 hours in Dickinson and Emmet Counties, IA.

7/03/93--5 inches in 2 hours in McCook County, SD.

7/09/93--11 inches overnight in Scranton, IA.

7/10/93--7 inches in just over 1 hour in Adrian, MN.

7/17/93--2 inches in 12 minutes in Montgomery County, IA.

12 inches in 3 hours near Baraboo, WI.

7/24/93--10 inches (in morning) near Finley, ND.

July 93--30.3 inches in Worth County, MO (90% of mean annual precipitation).

8/13/93--9.5 inches (overnight) in Leroy, MN.

Wettest summer (June-August) on record (since 1895), statewide average precipitation shown in parenthesis:

Idaho (6.08)	North Dakota (15.84)
Illinois (19.67)	South Dakota (13.27)
Iowa (26.90)	Missouri River Basin
Minnesota (17.24)	Upper Mississippi River Basin
Montana (9.83)	Souris-Red-Rainy Basin

Wettest January-August on record (since 1895), statewide average precipitation shown in parenthesis:

Idaho (16.39)	Minnesota (26.35)
Illinois (36.79)	North Dakota (20.68)
Iowa (41.26)	

14) Comparison to flooding of 1947: Similarities to this year include cool spring weather east of the Rockies, wet conditions from the central Plains to the Great Lakes states, and the development of major flooding in the upper Mississippi Valley in late June. However, this year (unlike 1947), heavy rainfall in the upper Mississippi area continued through July--a month longer than in 1947. Therefore, the flood crests were higher and lasted longer than in 1947. The only other time this century that widespread summer flooding occurred in these same areas was during June-July of 1951. During the 4 days preceding the 1951 flood, much of eastern Kansas and western Missouri received more than 10 inches of rain. Although this flooding was confined to a smaller area (mostly Kansas and Missouri), it claimed 41 lives, left 200,000 people homeless, and caused a billion dollars in property damage, with \$870 million damage in the Kansas City area.

15) The attached report (Atch 1--prepared by the Climate Analysis Center for the "Weekly Weather and Crop Bulletin") is an interesting study of summer rainfall vs. first freeze occurrence of the fall. Due to delays in planting caused by the heavy rainfall in the Midwest, there is great concern about harvesting being completed before the first fall freeze. In fact, this growing season thus far (March-August) has been the wettest on record for the primary corn and soybean belt.

SOUTHEAST DROUGHT/HEAT WAVE

1) The heat wave and drought in the Southeast, although less costly than the flooding, has been devastating for many of the area's farmers. During June-July, much of the area received less than 50% of normal rainfall along with temperatures 3-6 degrees above normal. The Southeast as a whole recorded the 2nd driest July on record (since 1895, driest was 1983). Also, the states of Alabama, Georgia, North Carolina, South Carolina, Tennessee, and Virginia had their hottest July on record (since 1895). So far, South Carolina is one of the hardest hit states, having had its driest June and 6th driest July on record, resulting in the following losses:

- Over 95% of corn crop lost.

- Over 70% of soybean crop lost.

- Over 50% of wheat crop lost.

- Over 25% of tobacco crop lost.

- Peach crop production down significantly but not quantified yet.

- 1.8 million chickens killed by the heat.

2) Much of South Carolina, North Carolina, Georgia, and Tennessee are now in the severe to extreme drought category according to the Palmer Drought Severity Index (PDSI). (The PDSI uses mathematical formulas to quantify each region's wet or dry spell.) However, due to unusually wet conditions during the fall of last year through the early spring of this year, hydrological impacts have thus far been minimal.

3) The death toll from a heat wave is very hard to calculate due to the occasional inability to determine if a death was truly caused by the heat. Deaths that are attributed to 'heat stress' are often included in evaluations. Preliminary reports indicate that the death toll now exceeds 100 for the Southeast and Northeast combined.

4) The monetary value of crop losses are preliminary and still climbing, but are currently estimated as \$264 million for South Carolina, \$165 million for North Carolina, and \$500 million for Georgia. The overall losses for the Southeast will probably exceed \$1 billion, especially if the drought continues well into the fall. So far, disaster areas have been declared as follows:

- South Carolina--all 46 counties.

- North Carolina--89 of 100 counties.

- Georgia--154 of 159 counties.

5) Some of the temperature records established include (all values in degrees Fahrenheit):

Asheville, NC (with a 92-year period of record)--25 days in July with 90 degrees or higher, breaking the old record of 18 days.

Several locations in the Southeast reported 90 degrees or higher every day in July, including Greenville-Spartanburg, SC; Chattanooga, TN; and Atlanta, GA.

Columbia, SC--17 consecutive days in July of 100 degrees or higher.

Atlanta, GA--7 days of 100 degrees or higher in July.

Augusta, GA--47 of 61 days with 95 degrees or higher, including 21 days with 100 or higher.

Hottest July on record (departure from normal in parenthesis):

Chattanooga, TN (+6.7)

Atlanta, GA (+6.7)

Philadelphia, PA (+6.5)

Knoxville, TN (+6.3)

Charlotte, NC (+6.2)

Athens, GA (+5.9)

Augusta, GA (+5.6)

Norfolk, VA (+5.4)

Columbia, SC (+5.4)

Greensboro, NC (+5.2)

Greenville-Spartanburg, SC (+5.0)

Beckley, WV (+4.9)

Newark, NJ (+4.9)

Asheville, NC (+4.7)

Richmond, VA (+4.7)

Louisville, KY (+4.7)

Roanoke, VA (+4.6)

Raleigh-Durham, NC (+4.5)

Lexington, KY (+4.4)
Evansville, IN (+4.3)
Erie, PA (+4.2)
Washington-Dulles, VA (+4.1)
Charleston, WV (+4.0)
Cape Hatteras, NC (+3.6)
Washington-National, DC (+3.2)
Tallahassee, FL (+2.0)

Hottest summer (June-August) on record:

Chattanooga, TN (82.0, with 85.2 in July!)

Newark, NJ (79.2)

Hottest summer (June-August) on record (since 1895), statewide average temperature shown in parenthesis:

Florida (82.3)

2nd hottest summer (June-August) on record (since 1895),
statewide average temperature shown in parenthesis:

New Jersey (74.3)

North Carolina (77.9)

South Carolina (80.7)

6) Some of the records established for drought include:

San Antonio, Austin, and Corpus Christi all recorded no measurable precipitation for at least 60 consecutive days.

Driest June on record:

Charlotte, NC (.15)

Greenville-Spartanburg, SC (.17)

Raleigh-Durham, NC (.33)

Driest July on record:

Charleston, WV (1.98)

Beckley, WV (1.65)

Greenville-Spartanburg, SC (.75)

Norfolk, VA (.36)

San Antonio, TX (.00)

Dallas, TX (.00)

Austin, TX (.00)

Waco, TX (.00)

Driest summer (June-August) on record (since 1895), statewide/regionwide average precipitation shown in parenthesis:

South Carolina (7.98)

Southeast region (10.37)

2nd driest summer (June-August) on record (since 1895),

statewide average precipitation shown in parenthesis:

Florida (14.70)

New Hampshire (7.23)

North Carolina (9.43)

Virginia (7.06)

CONCLUSION

1) So far, the federal government has allocated \$5.8 billion in disaster relief funds for the flood and drought-ravaged areas. The agencies involved in this disaster include: 1) the National Weather Service, 2) the Army Corps of Engineers, 3) the Coast Guard, 4) the Environmental Protection Agency, 5) the Federal Emergency Management Agency, 6) the Department of Agriculture, and 7) the Federal Housing Administration.

2) The second attached report (Atch 2--also prepared by the Climate Analysis Center) dramatizes the 'polarity' of the conditions experienced across the United States this summer. (On this graph, the 'wet area' percentages are inverted such that the true percentage is estimated by subtracting the percent figure on the vertical axis from 100%.) Due to the persistent trough west-ridge east pattern, a large portion of the country has been, and continues to be either unusually moist or unusually dry. At the end of August, this graph shows about 34% of the country to be unusually moist (unusual to extreme moist spell), and about 32% of the country to be unusually dry (moderate to extreme drought)--thus leaving only about a third of the country with near normal conditions. For example, from April through August, Des Moines, IA received 40.18 inches

of rain (compared to normal of 20.18), while Greenville-Spartanburg, SC received only 7.50 inches (compared to normal of 21.64 inches). Similarly, Salina, KS received 42.56 inches for the same 5-month period, while only 9.64 inches fell on Charlotte, NC.

3) To add insult to injury, preliminary data shows this summer to have produced 791 tornadoes across the country--a new record. However, the final count is always slightly lower than the initial total, so this is not yet an official record. Also, there have been several reports of softball-size hail in the areas hit by severe flooding, thus adding to the destruction. Some of the thunderstorm radar echo tops reached over 70,000 feet, being fueled by surface dew points that peaked in the low 80's. These 'supercell' storms generated some of the tornadoes mentioned above, and in some cases, produced microburst winds (non-tornadic) exceeding 100 MPH.

4) The National Climatic Data Center in Asheville, NC has several publications and digital datasets which provide much more detail about the events of this past summer. For information and ordering instructions, please contact the Climate Services Branch (phone 704-271-4800, fax 704-271-4876, internet orders@ncdc.noaa.gov)

ADDENDUM: RECENT WEATHER DISASTERS

During the past 12 months, the U.S. has been hit by 4 major weather 'disasters'--1) Hurricane Andrew, 2) Hurricane Iniki, 3) the March '93 "Storm of the Century," and 4) the flooding and drought of this past summer. The preliminary damage/costs estimates for these 4 events total nearly \$45 billion. The list below shows those weather events since 1980 which have caused at least \$1 billion in estimated damage/costs (including direct + indirect impacts). These disasters have placed a great strain on the affected federal, state, and local governments as well as the insurance industry. In fact, the past 6 years (1988-1993) have produced 7 weather-related disasters exceeding \$1.0 billion with total estimated damage/costs of \$93.4 billion.

Billion Dollar U.S. Weather Disasters 1980 - Mid 1993

1. Severe Flood--Summer 1993. Central U.S., estimated \$12.0 billion damage/costs so far, estimated 48 deaths.
2. Storm/Blizzard--March 1993. Eastern U.S., estimated at least \$6.0 billion damage/costs, estimated 270 deaths.
3. Hurricane Iniki--September 1992. Hawaiian island of Kauai, about \$1.8 billion damage/costs, 5 deaths.
4. Hurricane Andrew--August 1992. Florida and Louisiana, about \$25.0 billion damage/costs, 58 deaths.
5. Hurricane Bob--August 1991. Mainly coastal North Carolina, Long Island, and New England, \$1.5 billion damage/costs, 18 deaths.
6. Hurricane Hugo--September 1989. North and South Carolina, \$7.1 billion damage/costs, 57 deaths.
7. Drought/Heat Wave--Summer 1988. Central and Eastern U.S., \$40.0 billion damage/costs, estimated 5,000 to 10,000 deaths.

8. Hurricane Juan--October-November 1985. Louisiana and Southeast U.S., \$1.5 billion damage/costs, 63 deaths.

9. Hurricane Elena--August-September 1985. Florida to Louisiana, \$1.3 billion damage/costs, 4 deaths.

10. Hurricane Alicia--August 1983. Texas, \$2.0 billion damage/costs, 21 deaths.

11. Drought/Heat Wave--June-September 1980. Central and Eastern U.S., \$20 billion damage/costs, estimated 1300 deaths.

Figure 1

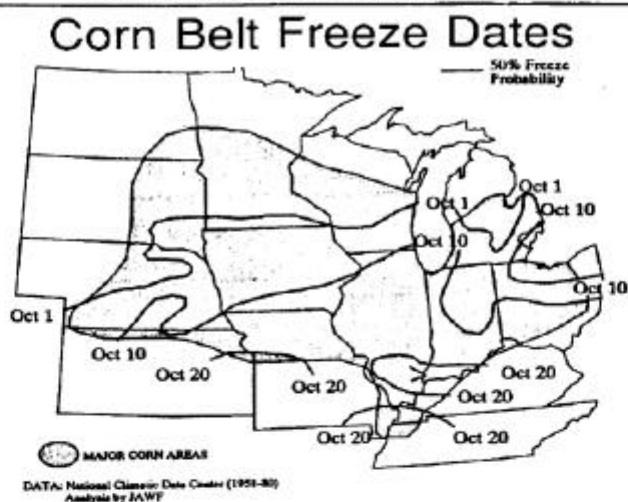
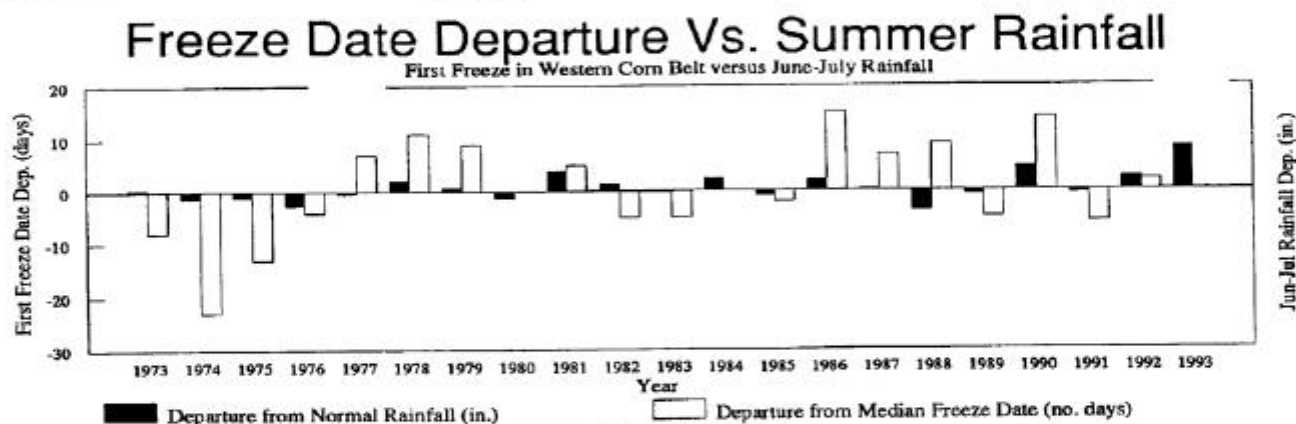


Figure 2



Freeze dates shown as number of days before (negative) and after (positive) the median date (September 26).

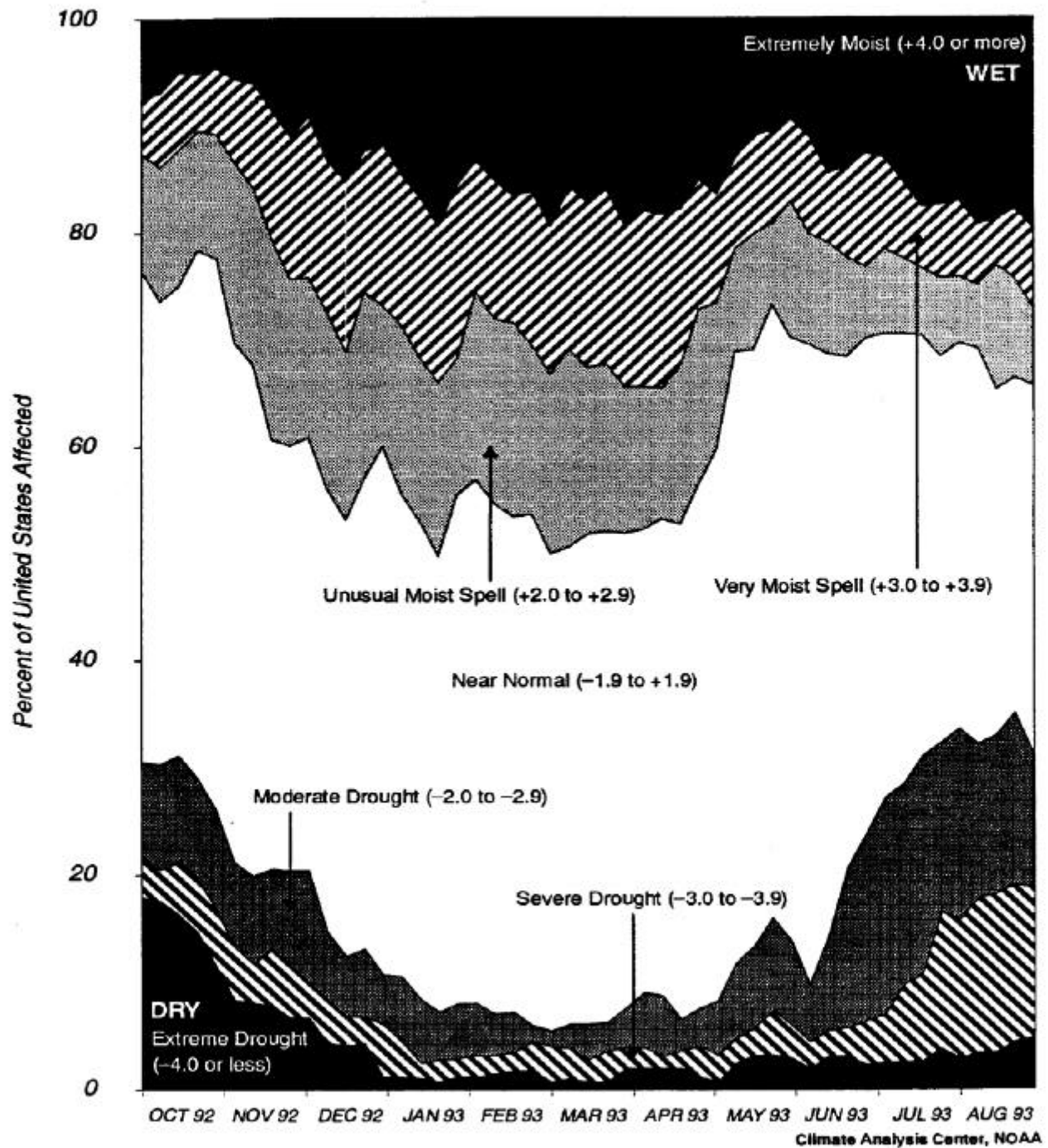
Rainfall shown as western Corn Belt June-July total (inches). Rainfall data courtesy of the National Climatic Data Center, NOAA.

Because of the late development of crops this year in the Corn Belt, there is considerable interest in knowing when the first freeze will occur. Based on 1951-80 data, the median date for the first 32-degree temperatures ranges from late September in the northwestern Corn Belt to late October in the southern areas (fig. 1). There have been media reports that the heavy rains received this summer in the western Corn Belt could lead to an early freeze. To test this premise, a preliminary historical analysis of first freeze dates for the past 20 years was made and these dates were compared with June-July total rainfall for the western Corn Belt (fig. 2). The "western Corn Belt" included Iowa and the surrounding climate divisions of the adjacent States. Rainfall during this period ranged from 3.77 inches during the 1988 drought to 15.71 inches in 1993. This year's deluge is unprecedented, as records going back to 1895 show no other June-July rainfall exceeding 14 inches. To check first freeze dates, past issues of the *Weekly Weather and Crop Bulletin* were examined for reports of 32-degree temperatures in the western Corn Belt. Such an analysis is somewhat subjective, as precise dates and extent of freezes were not always detailed. The goal was to obtain approximate dates of freezes that were more than local in nature. Based on 20 years of data, the median date of the first freeze was September 26. Dates ranged from September 3 (1974) to October 11 (1986). There were six cases where the June-July rainfall exceeded 9 inches. In each case, the first freeze occurred either at or later than the median date. Of the eight cases where rainfall was less than 7 inches, seven of the freezes occurred at or before the median date. This preliminary look at freezes versus summer rainfall is not intended as a forecast of a freeze occurrence this year, but it does give some insight into the recent history of summer rainfall and fall freezes.

Douglas Le Comte

PERCENT OF UNITED STATES AFFECTED BY A WET SPELL OR DROUGHT, BASED ON THE PRELIMINARY PALMER INDEX

OCTOBER 1992 THROUGH AUGUST 1993



Percent of Area Affected by Wet Spells and Drought, as computed by the Climate Analysis Center. Based on preliminary Palmer Drought Severity Index computed by climate divisions.